Center Innovation Fund: MSFC CIF

The Fabrication of Ultra-Light Full-Shell Replicated X-Ray Optics by 3D-Printing

Completed Technology Project (2016 - 2018)

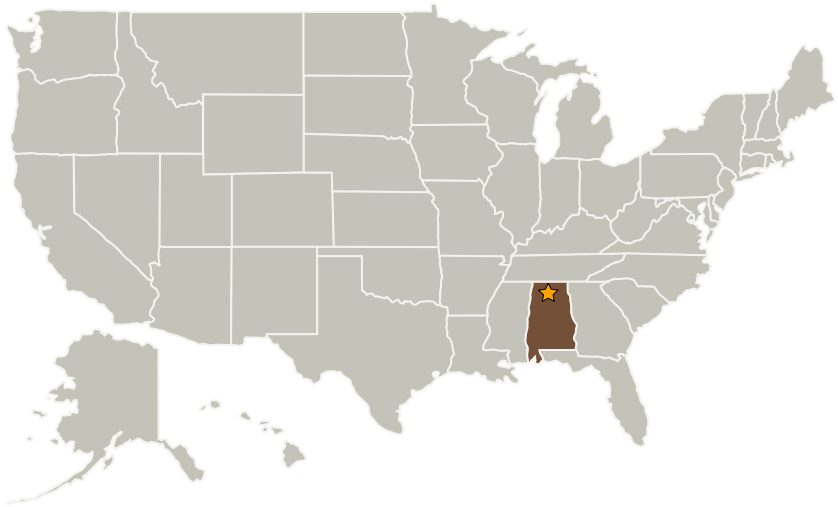
Project Introduction

The proposal seeks to demonstrate printing of material directly onto a precisely figured mandrel in order to eliminate secondary forming and polishing steps after the printing process. The first process is to electroform a very thin (i.e., 50 micron) layer of Ni onto a mandrel. Afterward the ceramic is printed onto the electroformed nickel, heat treated at low temperature, and then released. The second approach is to use a thin film release layer such as Titanium Nitride (TiN) which is deposited on the mandrel prior to printing of the ceramic. After printing the ceramic is heat treated at low temperature and then released.

Anticipated Benefits

The proposal offers a new approach to X-ray optics fabrication by replacing a portion of the thickness of traditional NiCo electroformed optics with a lightweight printed ceramic. This approach offers the potential to achieve a larger collecting area for a given mass budget in comparison to traditional electroformed optics.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Marshall Space Flight Center(MSFC)	Lead Organization	NASA Center	Huntsville, Alabama

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Primary U.S. Work Locations
Alabama

Project Transitions

October 2016: Project Start

September 2018: Closed out

Closeout Summary: We investigated the use of a ceramic AM process called pressurized spray deposition (PSD) developed by an industry partner HotEnd Works. The process utilizes a powdered ceramic and the selective application of a binding agent to produce complex 3D shapes. To achieve full densification, the printed ceramic must be fully sintered at a temperature ~1000C. Our intent was to combine our traditional NiCo electroforming process with this ceramic AM process to produce a lightweight hybrid X-ray optics. We found, however, that this AM process resulted in substantial cracking failures when heat treated at even modest temperatures of ~500C. We therefore have abandoned this AM approach and are now exploring an alternative method of ceramic AM developed by HRL Labs called polymer derived ceramics. Polymer derived ceramics have been shown to be superior to powder based ceramics, producing denser and crack free ceramics that exhibit low porosity. The polymer derived ceramics developed by HRL contains a pre ceramic resin that can be cured with UV light and utilized in commercially available stereolithographic printers. Our refined approach will start with fully sintered figured optics composed of SiC that have been formed using HRL's process. The figured ceramic optic will then be clad with a thin layer (~50 μM) of electroformed NiCo and subsequently polished to a surface finish suitable for achieving highly specular X-ray reflectivity. This process leverages MSFC's expertise in the fabrication of electroformed NiCo X-ray optics. An NDA has been signed by HRL labs and we anticipate to begin this work in the near future.

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VC

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Marshall Space Flight Center (MSFC)

Responsible Program:

Center Innovation Fund: MSFC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

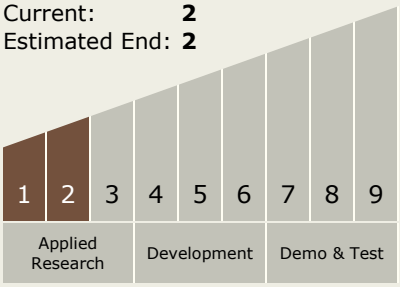
John W Dankanich

Principal Investigator:

David M Broadway

Technology Maturity (TRL)

Start: **1**
Current: **2**
Estimated End: **2**



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Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.4 Manufacturing
    - TX12.4.3 Electronics and Optics Manufacturing Process

Target Destinations

Others Inside the Solar System, Outside the Solar System